Sizing Soil Absorption Systems

An Evaluation of Tennessee's Onsite Wastewater System Sizing Criteria with a Special Focus on Alternative Porous Media Products

A Report to the Tennessee Department of Environment and Conservation – Division of Ground Water Protection

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Section One: Introduction

Onsite wastewater renovation systems have two objectives: To separate humans from pathogens and odors that are contained within wastewater (public health), and to minimize the negative impact that wastewater constituents could have on the receiving environment (environmental health). In suburban and rural America, the most common means of accomplishing these objectives is to pass domestic wastewater through a septic tank (pretreatment) and then transfer the effluent to a soil absorption field, where the effluent is distributed to the subsurface environment (final treatment). The basis for designing a subsurface system is the soil absorption rate and the wastewater daily volume. The various soil series within Tennessee have been rated for soil absorption based on soil characterization, soil series classification and results of field performance.

Issues

Conventional is No Longer Conventional

Effluent is applied to the subsurface soil environment via trenches. These trenches are excavations that are typically 24-30 inches deep by 36 inches wide and the length is on contour. A porous media is placed on the bottom of the trench. This media prevents the sidewalls from collapsing and allows the trench to be backfilled, thus maintaining the trench’s open structure. The media also promotes the gravity-distribution of the effluent along the trench length. Effluent infiltration into the soil takes place along the trench bottom and trench sidewalls. The infiltration rate through these surfaces plus the storage within the trench must be greater than or equal to the daily wastewater volume generated by the residence. If crushed rock is used as the porous media, by tradition and by rule, it is called a “conventional system.” As currently used, this terminology is ambiguous because manufacturers of alternative products have sought to achieve “conventional system” status. The term “conventional system” needs to be narrowly defined. For example, a conventional system could be defined as a gravity-based soil absorption system comprised of trenches that are 24 to 36 inches wide, are at least 24 inches deep, and include 12 inches of crushed rock that serves as a porous media.

Sizing the Required Absorption Area

Soil absorption areas have two tasks, both of equal importance. The first task is to finish renovating the effluent. This task is accomplished via the chemical, physical, and biological properties of the soil. The second task is to reintroduce the treated water back into the hydrologic cycle via the subsurface soil. When sizing soil absorption systems, this second task is the primary design parameter. The rate of water flux through the trench bottom and sidewalls is a function of quantifiable soil properties, such as texture, structure, porosity, and chemistry. When soil properties suggest a high infiltration rate, less absorption surface is needed to handle a given effluent volume. Likewise, soils with low infiltration rates demand more absorption surface area.

Loading Rate Nomenclature

The term “loading rate” is meant to mean the effluent volume that is applied to an infiltrative surface per unit time. In order to prevent confusion, this document will use “hydraulic loading rate” to define the vertical effluent flux into the soil and has traditional units of gallon per day per square foot (gpd/ft^2). When loading trenches with effluent, the hydraulic loading rate assumes that all the water passes through the trench bottom. Areal loading rate assumes that effluent is applied over the entire soil absorption system footprint. This includes the non-disturbed areas between the trenches.

Neither of these loading rates account for the sidewall infiltrative areas contained within the trench. This document will use the term “absorption area” to describe the total infiltrative area within a trench. Inclusion of sidewall in the determination of required absorption area has become pertinent because crushed rock is no longer the primary porous media used in trenches. Various products are now available that can serve as a replacement to crushed rock. However, these products may not provide the same amount of absorption area exposure to the effluent. An updated soil absorption sizing methodology is needed to account for how various in-trench products expose effluent to the absorption area within trenches.

Crushed Rock as a Porous Media

Crushed rock has been a widely accepted porous media for more than 70 years. Because of this history, crushed rock is often used as a standard for new product evaluation. However, crushed rock is not without issues that can affect septic system performance. It has been well-documented that aggregate fines negatively affect the absorption capability of the infiltrative surface (Amerson et al., 1991). As effluent moves through the aggregate, fines are washed to the trench bottom where they can occupy the voids between larger aggregates. This process can greatly reduce the porosity at the infiltrative surface. By Tennessee standards, fines are aggregates that can pass through a one half inch screen. By rule, the aggregate size distribution should allow for no more than five percent (by mass) passing a one-half inch screen and 90 percent should pass a 2-1/2 inch screen. However, this is a difficult standard to enforce, and it is difficult for quarries to meet this standard.

Several researchers and manufacturers have reported that as crushed rock is poured into the trench, the impact and weight of the rock creates a compacted surface on the absorption layer. A review of the research literature demonstrates that this concept is not universally accepted as being a problem. A third issue that has been raised is that rock will mask the infiltrative surface and thus reduce the flux of water into the soil. This concept of fines and masking were first mentioned by Otis et al. (1977). However, recent literature has failed to conclusively support the masking concept (White and West, 2003, Janna and Daugherty, 2007).

Crushed rock is expensive to transport and difficult to handle. The rock is typically delivered to the homesite and dumped near the trenches. After trench excavation, most installers will use standard boards to hold the corrugated pipe six inches off the trench bottom. Crushed rock is then scooped with a front-end loader and poured into the trench until a 12-inch media depth is achieved. The process of scooping and pouring the crushed rock provides many opportunities for soil to be entrained into the rock, thus adding to the mass of fine material.

Effluent In-Trench Storage

Various proprietary products claim to fix the problems associated with crushed rock. Most of these manufactured porous media products do not have fines, do not compact the infiltrative surface, and/or do not mask the infiltrative surface. Further, some of these products hold open larger voids within the trench and therefore have more effluent storage volume. While there is no historic precedence for determining the required in-trench storage volume, it is frequently assumed that crushed rock will provide at least two days of in-trench storage based on the design flow. Because some manufactured in-trench products have more storage volume, it has been suggested that less trench length is required when using those products.

Questions

The primary issue is that one product, crushed rock, has served as the porous media for many years without competition. Crushed rock was (and is) considered a constant and sizing the soil absorption system was (and is) based on the soil properties and daily wastewater volume. Now, it is no longer a given that crushed rock will be selected by installers and homeowners. Manufactured in-trench products have different characteristics, and thus, they will perform differently than crushed rock. When considering the differences between crushed rock and manufactured products, the following questions become pertinent.

- Should the design basis change for soil absorption systems that use porous media products other than crushed rock?
- Should each different trench product be allowed a different loading rate based the aggregate size (or lack of aggregate) and based on in-trench storage?
- How much storage is required within a trench?

Objective

The primary objective of this report is to recommend a soil absorption system sizing criterion that will provide consistent evaluation of current and future drainfield products.

Solution

In order to accomplish this objective, a consistent soil loading standard must be adopted. The current regulations demonstrate little consistency in soil loading rates among the various trench media products. It is the author's opinion that the lack of a consistent loading rate puts TDEC-GWP in a weak position to defend how the Division sizes septic systems.

The second part of the solution is to understand the absorption surface area provided by each of the drainfield products. The in-trench products must be able to uniformly distribute effluent across the length and width of the absorption surface, and provide for in-trench storage. Once these parameters are known, then the soil absorption system sizing can be based on providing the appropriate soil loading rate for the soil type and anticipated wastewater volume.

What is proposed by this report is an overhaul of the current regulations for gravity-based effluent dispersal. What is needed is a defendable, science-based approach to sizing systems. The proposed changes are based on developing a consistent means of determining the absorption surface area provided by various in-trench products. Once the absorption surface area is known, then a consistent loading rate will be used to size trenches. Products that go into trenches will have to satisfy certain minimum parameters such as porosity and storage.

Installation Issues

This document assumes uniform effluent distribution to all trenches. In practice, this is a poor assumption. In most installations, some degree of ponding must occur before effluent will move throughout the whole system. On sloping sites, the use of serial distribution is very common. This installation configuration forces effluent to move serially through the system. The end result is that the first trench must be flooded in order for effluent to move into the next trench. If effluent were “clean water” then all the rules discussed in this document would apply equally to serial and parallel systems. However, the effluent contains organic matter and other constituents. Therefore, in serial distribution, the first trench will receive a much higher organic load. As a result, wastewater constituents remaining after organic bio-degradation will form a hydraulically restrictive layer (biomat) on the trench absorption surface. As already mentioned, this document is focused on the relationship between porous media and soil absorption. Future review of soil-based wastewater treatment regulations need to address the issue of uniform distribution. Such a review might consider having the first trench significantly shorter than the second trench when serial loading to force a larger percentage of effluent into the second trench.

Progression of Author’s Recommendations

In the development of this document, it was challenging to present a clear argument for the wide range of changes that are needed in the current regulations. This document is divided into various sections that have specific recommendations. There are several instances where one section affects the recommendations made in a previous section. Thus, the recommendations and their affects on various soil absorption systems will build as this document progresses.

Section Two: Baseline Loading Rates

Conventional Hydraulic Loading Rates

Tennessee does not directly specify hydraulic loading rates in the regulations (Chapter 1200-1-6). Instead, the loading rate is indirectly specified in terms of a daily design wastewater volume (150 gallons per day per bedroom) and a design application area. Using this information, the hydraulic loading rate for the rated soils were calculated and the results are listed in table 1. Using a crushed rock system as an example, a three-bedroom home on 60 minute per inch (mpi) soil, would require a series of trenches that have a total trench-bottom area of 990 square feet. The hydraulic loading rate would be 450 gallons per day per 990 square feet or 0.45 gpd/ft^2.

Table 1. Trench-bottom hydraulic loading rates for a traditional crushed rock system installed in various percolation rate soils.

Soil Rating (mpi)	Trench Bottom Area Requirement per Bedroom (ft^2)	Calculated Hydraulic Loading Rate (gpd/ft^2)
10	165	0.91
15	190	0.79
30	250	0.60
45	300	0.50
60	330	0.45
75	370	0.41
80	380	0.40
85	390	0.38
90	400	0.38
95	415	0.36
100	430	0.35
105	445	0.34

Hydraulic Loading Rate History

It is understood that the conversion from “minutes per inch” to “gallons per day per square foot” can be conducted mathematically but it has no physical meaning. Percolation tests are three-dimensional and loading rates are only two-dimensional. Thus, it is common to take quantitative percolation values and assign qualitative loading rates. In 1967, the former U. S. Department of Health, Education, and Welfare published the third edition of the *Manual of Septic Tank Practice.* This document provided guidance to states in the development of local codes for onsite wastewater disposal. Hydraulic loading rates (square feet per bedroom) are based on the percolation rating of the soil. These values were later reprinted in the 1980 U.S. EPA design manual. For all intent and purposes, Tennessee adopted these loading rate values, which are listed in table 2.

Table 2. Percolation rates and loading rate values reprinted from U. S. EPA (1980).

Soil Texture	Percolation Rate (mpi)	Hydraulic Loading Rate (gpd/ft^2)
Gravel, coarse sand	<1	not suitable
Coarse to medium sand	1 - 5	1.2
Fine sand, loamy sand	6 - 15	0.8
Sandy loam, loam	16 - 30	0.6
Loam, porous silt loam	31 - 60	0.45
Silty clay loam, clay loam	61 - 120	0.2

36-inch Wide Vaulted Products

Because our understanding of how subsurface dispersal systems operate is based on our experience of using crushed rock as a trench media, it is appropriate to question whether systems should have a different design basis when media substitutes are employed. In the January 3, 2000 amendment to the Chapter 1200-1-6 regulations, vaulted products that are 32-36 inches wide by 10-12 inches high were approved for use in Tennessee. Once a particular vaulted-product is approved by the Division, that product can be installed at a 30% linear footage reduction (in soils rated between 10 and 60 mpi) as compared to a three-foot wide trench with crushed rock. Nearly all other states have adopted similar sizing reductions (Lake, 2000). By decreasing the linear trench footage, the application area is also reduced and thus, the loading rate for vaulted systems is greater than for crushed rock systems. Table 3 provides a direct comparison of the two different hydraulic loading rates by rated soils.

Table 3. Direct comparison of loading rates used for conventional crushed rock systems and 36-inch wide vaulted systems.

Soil Rating (mpi)	Crushed Rock Hydraulic Loading Rate (gpd/ft^2)	Established 36-inch Wide Vaulted Hydraulic Loading Rate (gpd/ft^2)	Percent Increase in Loading Rate
10	0.91	1.30	43%
15	0.79	1.13	43%
30	0.60	0.86	43%
45	0.50	0.71	42%
60	0.46	0.65	41%
75*	0.41	0.41	0%
80*	0.40	0.40	0%
85*	0.38	0.39	0%
90*	0.38	0.38	0%
95*	0.36	0.36	0%
100*	0.35	0.35	0%
105*	0.34	0.34	0%

*Sites with soil absorption rates greater than 60 mpi are currently not allowed length reductions and therefore, the loading rate is the same as rock media.

As noted in table 3, the 30% reduction in length converts to a loading rate increase of more than 40%. This increased application rate seems to be justified because vaulted products do not contain aggregate fines and will not compact the absorption surface during installation. Since January of 2000, there has not been a documentable increase in soil absorption system failure; therefore, one can argue that table 3 provides an acceptable loading rate for products that do not contain fines nor compact the infiltrative surface.

Because the length reduction is based on improved infiltration characteristics, one should question whether the length reduction is appropriate for all rated soils. Table 4 provides a listing of hydraulic loading rates for 36-inch wide vaulted products if length reduction were to be allowed for all rated soils. For the purpose of this document, it will be assumed that all rated soils will be eligible for trench length reductions. In other words, in-trench products that qualify for a trench length reduction in soils rated between 10 and 60 mpi will also receive a trench length reduction in soil rated greater than 60 and equal to or less than 105 mpi.

Table 4. Trench length and trench-bottom area assuming all rated soils could receive the trench-length reduction – as compared to a 36-inch wide crushed rock system (on a per bedroom basis).

Soil Rating (mpi)	Trench Length with 30% Reduction (ft)	Trench Bottom Area with Reduced Length (ft^2)	Hydraulic Loading Rate with Reduced Length (gpd/ft^2)
10	39	117	1.30
15	44	132	1.13
30	58	249	0.86
45	70	210	0.71
60	77	231	0.65
75	86	258	0.58
80	89	267	0.58
85	91	273	0.55
90	93	279	0.54
95	97	291	0.52
100	100	300	0.50
105	104	312	0.48

Standards for Loading Rates Based on Fines in Media

This author makes two assumptions: 1) that the hydraulic loading rate for a rock-based media is acceptable, and 2) the hydraulic loading rate for wide chamber products is acceptable. Assumption two is not based on vaulted products but rather, based on a fines-free product that does not compact the soil surface during installation. Using these two hydraulic loading rates, it is hereby recommended to remove any language from the regulations that suggests a reduction in trench length and instead mandate a hydraulic loading rate that is based on soil type, and based on the absorption surface area provided by the product. Once the hydraulic loading rate is established, then the length of the trench will be determined by the actual absorption surface area provided by the media and the daily design wastewater volume. For example, using table 3, all media products that are subject to having fines will have a loading rate based on column number 2. All media products that do not have fines and do not compact the infiltrative surface will use the hydraulic loading rate in column number 3.

Section Two Recommendations:

- *For all rated soils there will be two hydraulic loading rates established in regulations.*
    - *The first hydraulic loading rate would be used for porous media products that could contain fine aggregates and could compact the infiltrative surface. Fine material should be limited to five percent by mass that can pass through a 0.5 inch screen.*
    - *The second hydraulic loading rate would be used for porous media and vaulted-products that are shown to be free of fines and will not compact the infiltrative surface of the trench.*

Section Three: Total Absorption Area as a Design Parameter

Absorption Area

In the preceding discussion, the hydraulic loading rate was used to describe the volume of water that would pass through the trench bottom on a daily basis. In the current regulations, the trench bottom area is the design parameter for the required infiltrative area. It is well known that trench sidewalls provide effluent absorption; however, that phenomenon is considered a hidden safety factor in system design. As a porous media, crushed rock provides full sidewall exposure. If the trench is ponded, then effluent can move through the sidewalls and into the soil. At issue is whether all alternative porous media products provide the same trench bottom and sidewall exposure. In order to account for differences among products, the absorption surface area provided by the product must be compared with the absorption area required to transmit effluent into the soil. For the remainder of this document, the combination of the effective trench bottom and sidewalls will be referred to as the absorption area.

Trench Bottom Area

As previously mentioned, the trench bottom has been (and is) the primary design parameter. For most installations, a 36-inch wide excavation bucket is used to open a trench. Alternative products, which range from 32 to 36 inches wide, are installed and the trench bottom area calculation is based on a 36-inch width. Because of the potential confusion that arises with products that are not equal to the excavated trench width, in-trench systems should be sized based on the actual width of the product. In other words, a 32-inch wide vault would have a bottom surface area of 2.67 ft^2/ft of trench length. Likewise, a 24-inch wide trench with crushed rock would have an infiltrative surface area of 2.0 ft^2/ft of trench length. This procedure is both logical and defendable.

Sidewalls

As stated in Chapter 1200-1-6, crushed rock trenches are 24 to 36 inches wide and must have at least 12 inches of crushed rock on the trench bottom. Because crushed rock allows full effluent exposure to the sidewalls, it is fully expected that some effluent volume will leave the trench via the sidewalls. Using the area provided by a 36-inch wide trench as a standard, the potential absorption area includes the two sidewalls and the trench bottom, for a total of five square feet of absorption area per foot of trench length. For simplicity purposes, it is suggested that sidewalls on each end of a trench not be included in the design calculations.

Are Bottoms and Sidewalls Equal

As recommended, the required absorption area should be based on the absorption area available in a 36-inch wide trench. At this width, there is a 60% - 40% ratio of absorption area between the trench bottom and the sidewalls, respectively. An immediate repercussion of this sizing methodology is that the ratio of bottom area to sidewall area changes with trench width. If a crushed rock system was installed in 24-inch wide trenches using this methodology, the trench bottom to sidewall ratio would be 50%-50%. For example, in a 60 mpi soil, 550 ft^2 of absorption area would be required per bedroom. Using methodology shown in table 5, the trench length for a two-foot wide trench would be 138 feet. This configuration would have 276 ft^2 of trench bottom and 276 ft^2 of sidewall. Under the current regulations, a 24-inch trench width would require the trench length to be 165 feet per bedroom. This new methodology would create a 16% reduction in trench length. This situation presents two potential arguments.

> <u>Argument one:</u> narrow trenches (less than 36 inches wide) should be allowed a greater allowance for sidewall absorption. The sidewalls are in closer proximity to the soil surface and therefore are more likely to have aerobic conditions. According to Erickson and Tyler (2001), narrow trenches provide greater opportunity for gas transfer. This increases the possibility of maintaining aerobic conditions in the soil just below the infiltrative surface. Under aerobic conditions, soil microbes are more efficient at degrading organic carbon. This phenomenon reduces build up of biomat on the infiltrative surface. However, care must be taken to

ensure that the minimum in-trench storage can be maintained with any reduction of trench length.

Table 5. Minimum absorption area required per bedroom, assuming influence of sidewall.[a]

Soil Rating	Porous Media with Fines		Porous Media without Fines	
(mpi)	Absorption Area Requirement per Bedroom[b] (ft^2)	Absorption Area Loading Rate (gpd/ft^2)	Absorption Area Requirement per Bedroom[c] (ft^2)	Absorption Area Loading Rate (gpd/ft^2)
10	275	0.55	195	0.77
15	317	0.47	220	0.68
30	417	0.36	290	0.52
45	500	0.30	350	0.43
60	550	0.27	385	0.39
75	617	0.24	430	0.35
80	633	0.24	445	0.34
85	650	0.23	455	0.33
90	667	0.22	465	0.32
95	692	0.22	485	0.31
100	717	0.21	500	0.30
105	742	0.20	520	0.29

[a] Assumes the area of a 36-inch trench width and 12-inch deep sidewall.
[b] Assumes the loading rate based on fine aggregates and compacted surface.
[c] Assumes fines-free and non-compacted surface.

<u>Argument two:</u> the trench bottom conducts most of the effluent into the soil and therefore, the maximum bottom area should be preserved. While the benefit of the sidewall should be recognized, under saturated conditions, gravity will still pull most of the effluent through the bottom surface. Since a 36-inch wide trench has a 60% bottom surface, and because 36-inch trenches are often held as a “standard,” then it could be argued that all gravity-based soil absorption system should have a minimum of 60% of the absorption area on trench bottom.

Both arguments are valid. Because of past struggles to force homeowners to have sufficient suitable soil for the installation of a given trench length, it is difficult to allow any reduction in the future. However, in order to develop a consistent means of septic system sizing, this reduction is a worthy sacrifice. For the purpose of this document, the author will further explore the implications of argument one – systems should be based on the total, available in-trench absorption area, regardless of how trench length and bottom area are affected.

Sidewalls and Trench Volume

The effectiveness of sidewalls depends on effluent ponding. If the effluent is never more than one inch deep, then the upper 11 inches of the sidewall is never utilized. Crushed rock occupies 60 to 70% of the trench volume. A given volume of effluent may have an eight-inch depth within the crushed rock; and therefore, expose eight inches of sidewall. However, using a vaulted product, this same effluent volume in the same trench length may only have one inch of effluent depth. Thus the effluent depth will be dependent on whether trench is held open with a vault or by a porous media. The issue of actual effluent depth needs to be incorporated into the determination of effective sidewall allocation.

Sidewall Allocation

Two assumptions will be used in the absorption area calculation. First assumption is that 12 inches is the maximum allowed sidewall depth – regardless of the porous media or vaulted product configuration. In other words, if 18 inches of crushed rock were to be placed in a trench, only 12 of the 18 inches will be allowed in the absorption area calculation. The second assumption is that the allowed sidewall depth for various in-trench products will reflect the ability of that product to expose effluent to the sidewall. For example, various vaulted products have various depths of sidewall louvers, and these depths range from 6 to 10 inches. As discussed above, vaulted products have an open volume and create little ponding within the trench. It is suggested that all vaulted products, which have louvers between 6 and 10 inches deep, be assigned an effective depth of 6 inches. This depth better represents the anticipated ponding depth rather than the full louver depth. Other alternative products and their potential sidewall depth assignment will be provided in Section Five.

Section Three Recommendations:

- *In order to better represent the ability of various in-trench products to convey effluent to the absorption area, it is recommended the sidewall effects should be included in soil absorption system design.*
- *To prevent confusion, when incorporating trench bottom and sidewall area, this total area should be referred to as the total absorption area. When referring to just the trench bottom, this is the hydraulic loading rate.*
- *For in-trench products that do not include any barrier between the effluent and the sidewall, the maximum sidewall allocation should be 12 inches*
- *For in-trench products that obstruct the sidewall or have minimum ability to pond effluent, sidewall depth allowance should be limited to six inches.*

Section Four: In-Trench Effluent Storage

The Purpose of Porous Media

The research literature provides very little guidance for the determination of an appropriate storage volume within an effluent dispersal trench. Otis et al. (1977) indicated that a porous media within a trench serves four basic purposes. The primary purpose is to provide a media through which the septic tank effluent can flow from the distribution pipe to the absorption surfaces. The trench bottom is the primary absorption surface, and the porous media allows for the whole surface to receive effluent. Several authors have reported on the advantages of having a porous media occupy the trench volume in order to raise the effective depth of the effluent such to make more of the trench sidewall available for infiltration (White and West, 2003).

Otis et al. (1977) stated that the second function is to provide storage of peak flows of effluent. This is the first time that the word “storage” is used in the literature. The intent of providing storage for peak flows is for when flow enters the trench system at a rate greater than water can leave the system. In regard to the peak flow duration or to the total volume of peak flow, there is little design guidance in the research literature. A possibility exists that a family might have two showers going at the same time that the washing machine and dishwasher are running. Such a scenario could put 200 gallons into the trench system in a very short time.

The third function is that the media dissipates any energy incoming effluent may have that could erode the infiltrative surface. This may be an issue that needs to be addressed with vaulted products. And finally, when placed over the pipe, the forth function helps to insulate the pipe not only from freezing but also from root penetration. Since Richard Otis is in Wisconsin, this fourth function may be a little less important to Tennessee.

Rubin and Janna (2006) published the most recent study on surge volume and storage requirements. These authors outlined a rational approach that accounted for the different infiltration rates of the trench bottom and sidewalls, the instantaneous inflow of wastewater, and the storage within the septic tank. The end result is a custom storage value for each site. While this is a scientifically valid approach, it is not realistic in practice. The regulatory community needs a storage value that is consistent and enforceable. As an example, many regulators use the traditional value of two days of design flow for in-trench effluent storage. In Tennessee, this value is 300 gallons per bedroom.

It is the opinion of this author that the issue of storage (beyond 300 gallons per bedroom) is somewhat artificial. As various manufacturers of in-trench media products have advertised the advantages of their specific product, some have listed increased storage volume as a means to justify a reduction in soil absorption area. A simple mass balance can be used to minimize these claims – water in must equal water out. The primary design criteria must be the infiltrative surface area. If the soil will not accept the effluent, then additional storage only delays the evidence of system failure.

Crushed Rock Effluent Storage

Assuming a porosity of 30% (volume of voids divided by the total volume), the assumed water holding capacity of 12 inches of crushed rock becomes 0.3 cubic foot of water per one cubic foot of media, or 2.2 gallons of water per cubic foot of media (plus the volume of the corrugated pipe). Using Chapter 1200-01-06, Appendix II for the sizing of gravity systems, table 6 was created to demonstrate the volume of storage provided by crushed rock systems installed on the various soil types.

Table 6. Effluent storage within crushed rock as installed on various soils in Tennessee (assuming 30% porosity).

Soil Rating (mpi)	Trench Bottom Area Required per Bedroom (ft^2)	Effluent Storage in Crushed Rock Media per Bedroom[a] (gallons per bedroom)
10	165	370
15	190	426
30	250	561
45	300	673
60	330	741
75	370	830
80	380	853
85	390	875
90	400	898
95	415	931
100	430	965
105	445	999

[a] These figures do not account for the presence of the 4-in diameter corrugated pipe.

Hardened Polystyrene Aggregates from Ring Industrial Group

Engineered and hardened polystyrene aggregates, manufactured by Ring Industrial Group, are a mineral aggregate replacement that is fines free, lightweight, and will not compact the infiltrative surface. Because the in-trench characteristics of the polystyrene product are largely unknown, TDEC-GWP has been hesitant to promulgate regulations that allow this product to be installed with a linear reduction as compared to crushed rock. The Division authorized the University of Tennessee Institute of Agriculture to study the storage volume contained within the polystyrene products that are marketed by Ring Industrial Group. This study attempted to better understand how the polystyrene product would respond under field conditions.

In order to simulate compressive effects, samples of hardened polystyrene were removed from the netting, and placed in a rigid, upright cylinder. The volume occupied by the loosely packed polystyrene aggregate was determined and the porosity was determined to be 45%. A constant force of 125 pounds per square foot was placed on the product within the cylinder. This pressure was chosen to represent the weight of two feet of backfill. After five days of constant pressure, the change in volume was measured. By filling the compressed void volume with water, it was determined that the compacted porosity is approximately 33% and the overall volume is reduced by 19%. A back calculation determined that the aggregate volume was only reduced by 2%. This series of tests indicated that under compressive conditions, the inter-particle bridging will compress into the previously available void volume. It must be understood that this test is only a measurement of the polystyrene compression within a test cylinder.

EZFlow™ 1203

EZFlow ™1203 consists of three 12-in diameter bundles, and the center bundle contains a 4-in diameter corrugated pipe. Using a controlled-volume chamber, porosity was measured with no simulated overburden. The mean measured aggregate porosity (without the corrugated pipe volume) was a .39 with a standard deviation of 0.01. Using this value, it is estimated that the storage volume contained within Ring's EZFlow™ 1203 under non-compacted conditions is 7.3 gallons per foot of trench. This volume per length only assumes the storage within the product netting (not the spaces between the bundles) and assumes the full capacity of the four-inch diameter corrugated pipe contained within the center bundle.

In an *in-situ* study conducted in Orange County, North Carolina, Jeffrey Karl, engineer with Ring Industrial Group, measured 2.2 inches (on average) of settling after the application of four feet of backfill on EZFlow™1203. Using this information, in combination with the knowledge gained from the author's study, a graphical model of the EZFlow™ 1203 was created (figure 1). In the development of this model, it was assumed that the granular overburden would maintain the rounded top half of each bundle. Further, because the trench sidewalls are rigid, it was assumed that the bundles could not become wider.

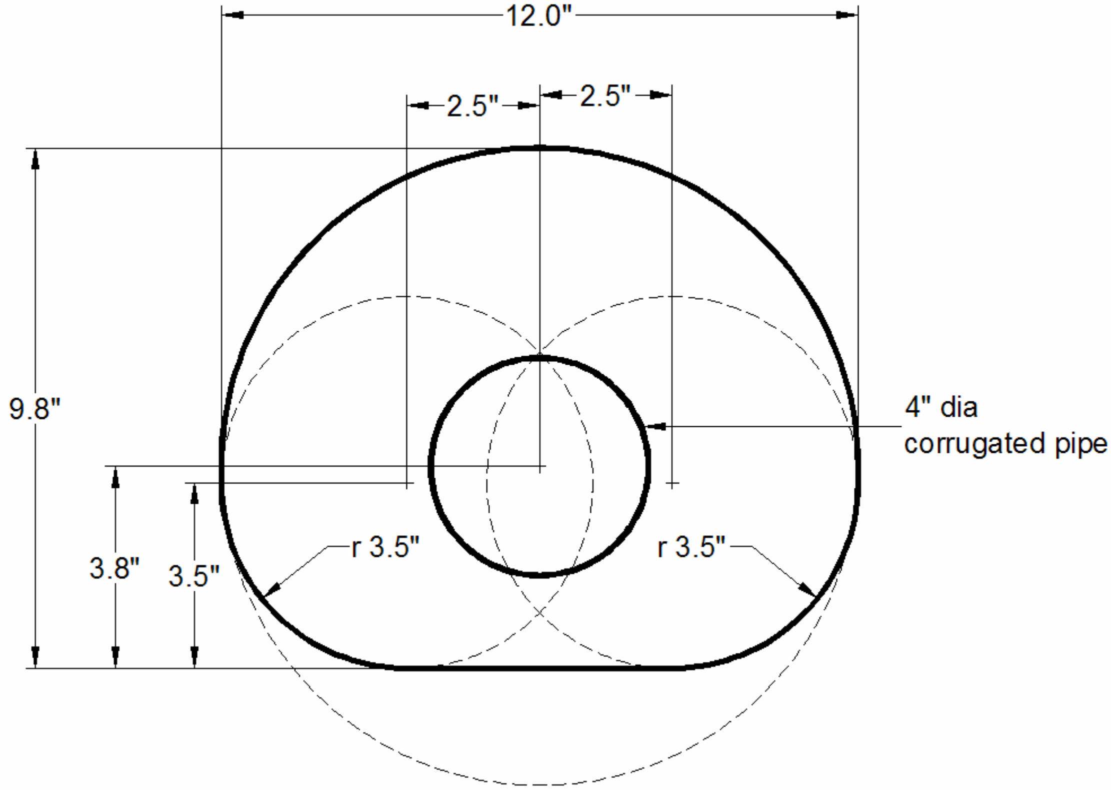

Figure 1. Graphical model of the compressed cross-section of EZFlow 1203.

Thus, any reduction in height would have to correspond to a flattening of the bottom half of each bundle. Using AutoCAD, the author experimented with various deformed cross-sections. Using height of 9.8 inches, a cross-section was created that is a reasonable model of the EZFlow™ 1203 product under compaction conditions. The theoretical cross-section of a 12-inch diameter bundle is 113.1 in^2. Simulated compaction reduced the cross sectional area to 96.9 in^2, a 15% reduction. Because it was shown in the author's study that the hardened polystyrene aggregate does not have a significant dimensional change during soil-based compression, it was assumed that the volume reduction is a direct indicator of the product's pore volume reduction. Before compaction, the individual bundles were measured to have 0.78 cubic feet of total volume per foot of length (ft^3/ft) and a measured porosity of 45%. For each foot (length), a bundle has 0.35 ft^3 of voids and 0.43 ft^3 of aggregate. Based on the graphical model, the compressed volume was estimated to have a total volume of 0.67 ft^3/ft – a reduction of 0.11 ft^3/ft. Since the solids volume does not significantly change, then the 0.11 ft^3/ft is a reduction of the non-compacted void volume. This leaves 0.24 ft^3/ft of voids and a final porosity of 36% within the polystyrene aggregate bundle. At 36% porosity, the two outside bundles were estimated to have 3.61 gallons of voids per foot. The center bundle was estimated to have 2.24 gallons of voids, including the 4-in diameter pipe. As a whole, the EZFlow™ 1203 product has been estimated to contain 5.85 gallons per foot of length (figure 2). The lower half of the annular cross-sectional area between the bundles was estimated to contain 1.09 gallons per foot. This model, therefore, estimated the total water storage of the EZFlow™ 1203 under *in-situ* conditions to be 6.93 gallons per foot, which is close to 6.1 gallons per foot that was measured *in-situ* by Quisenberry et al. (2006).

Because of the consolidation, EZFlow™1203 is better represented as having a 10-inch depth of porous media. Therefore, it is recommended that the determination of the available absorption area should be based on a 10-inch sidewall. This produces an effective absorption area of 4.66 ft^2 per foot of trench length. Table 7 displays how the recommendations for storage and absorption area affect the required trench length.

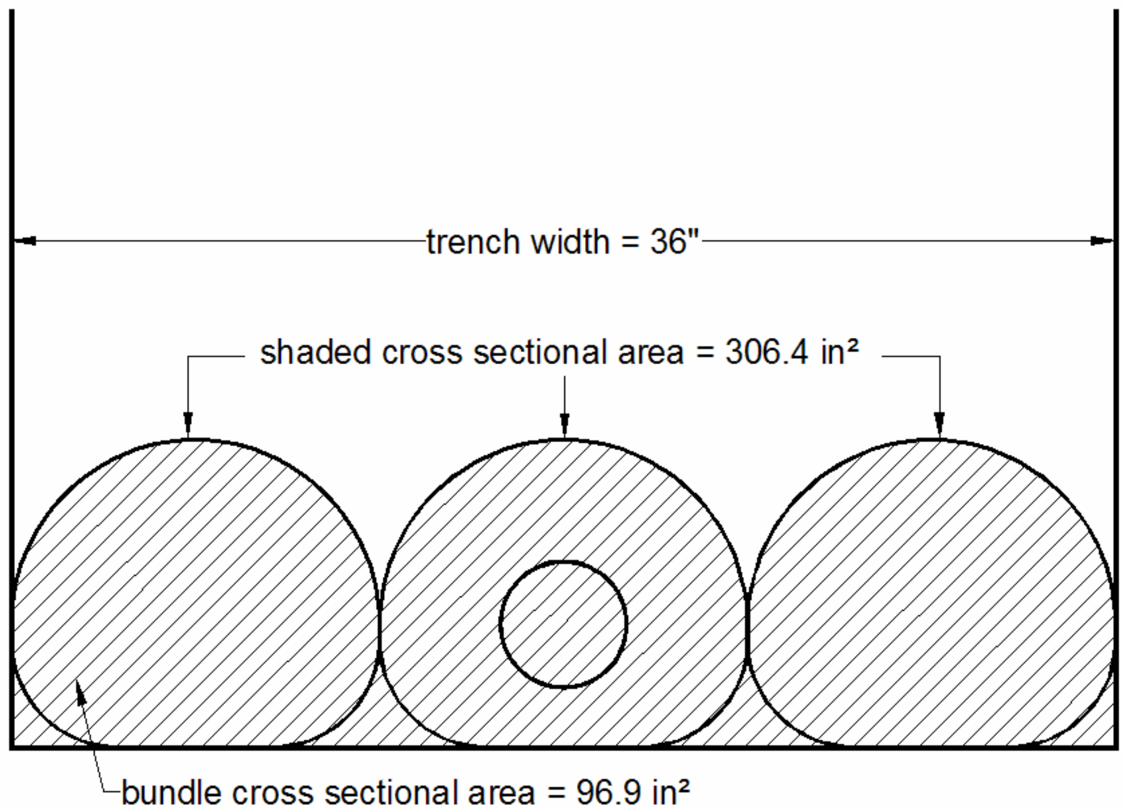

Figure 2. Graphical representation of the estimated compaction of EZFlow 1203 as installed

Table 7. Trench length required to provide the needed absorption area and/or effluent storage when using EZFlow™ 1203.

Soil Rating (mpi)	Absorption Area Requirement per Bedroom[a] (ft^2)	Trench Length Required per Bedroom[b] (feet)	Effluent Storage in Compacted EZFlow™ 1203 per Bedroom[c] (gallons per bedroom)
10	195	43[d]	300
15	220	47	324
30	290	62	428
45	350	75	518
60	385	83	573
75	430	92	635
80	445	95	449
85	455	98	676
90	465	100	690
95	485	104	718
100	500	107	738
105	520	112	773

[a] Assumes the fines-free absorption area loading rate.
[b] Assumes 4.66 ft^2 of absorption surface per foot of trench.
[c] Assumes 6.9 gallons of storage per foot of trench.
[d] At 10 mpi, the length was based on storage.

EZFlow™ 1401

Ring Industrial Group manufactures EZFlow™ 1401 as a porous media for narrow trenches. This product has a nominal 14-inch diameter and contains a 4-inch diameter corrugated pipe in the center of the bundle. In general, excavation contractors do not have 14-inch wide buckets, and so it is expected that the actual trench width would be either 18 or 24 inches. It is Ring's installation recommendation to place EZFlow™1401 against one sidewall and then backfill the open bottom. If this procedure is followed, then it is reasonable to assume rigid sidewalls. Consolidation of the polystyrene aggregate should result in a deformation of the bundle's bottom half.

It was assumed that EZFlow™1401 would have the same percentage of consolidation as EZFlow™1203H. Thus, a graphical model was developed that allowed for a consolidated height of 11.4 inches. The theoretical cross section of the EZFlow™1401 product is 154 in^2. As mentioned, this product has a 4-inch diameter corrugated pipe within the polystyrene aggregate. Under non-compacted conditions, this product was measured to have nearly 50% porosity or 4 gallons per foot of length. By removing corrugated pipe void volume, it was determined that the polystyrene aggregate contains 3.35 gallons per foot.

After the simulated compaction, the cross sectional area was reduced to 132.12 in^2 – a 14% reduction (figure 3). Assuming that this compaction occupied previous voids within the aggregate, it was estimated that a pore volume of 1.14 gallons was lost and the compacted water holding capacity becomes 2.86 gallons per foot. Section 5 includes more discussion of EZFlow™ 1401, including table 12 that provides a comparison of how this proposed methodology affects the required trench length.

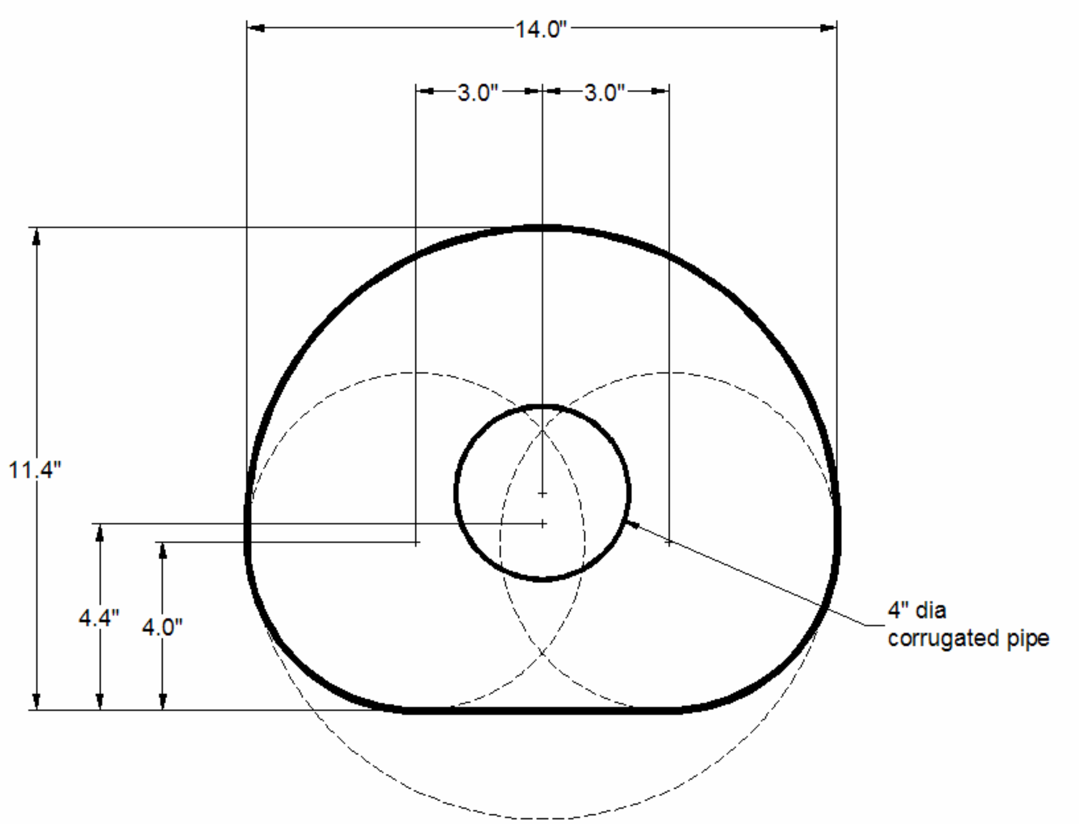

Figure 3. Graphical estimation of EZFlow 1401 under compaction.

Discussion of Trench Media and Storage

Because hydraulic loading rate and effluent storage are inversely related, the amount of storage increases as loading rate decreases. In other words, as the regulations specify longer trenches, more effluent storage is available. High loading rate soils will have the least amount of storage, which stands to reason because it is less likely that ponding will occur in the trench. A restrictive biomat is less likely to occur when there is no ponding. It also stands to reason that low loading rate soils needs more storage because these soils are more susceptible to ponding, and it is more likely that the biomat will become more limiting than the soil's hydraulic properties.

The question remains, how should effluent storage figure into the sizing criteria for soil absorption systems? Several states (i.e., Georgia and Washington) have polices that dictate that all trench media products must have at least the same storage capacity of a 12-inch thick layer of crushed rock. If this standard were to be applied in Tennessee, regulations for LDGP and for EZFlow™ products placed in high loading rate soils would have to be amended.

Other states have taken the approach that all in-trench media must have at least 30% porosity. All products currently permitted in Tennessee can meet this criterion. As suggested by Otis et al. (1977), the first priority for a porous media is to promote the distribution of effluent across the length and width of the trench. Tennessee's current standard prevents the use of crushed rock that contains greater than five percent fine material (material that passes through a 0.5-inch screen) from being used as media. This standard could apply to any material – such as tire chips or polystyrene. It is recommended that all trench media products should have to meet this same standard and be able to demonstrate that effluent can travel through the media to the infiltrative surface. For new products entering the market, such demonstrations would be conducted by installing observation ports (down to the infiltrative surface) throughout the trench length and width when evaluating new products.

Section Four Recommendations:

- *All in-trench aggregates (whether inorganic or organic based) should have 90 percent of the material pass a 2.5-inch screen with only five percent passing a 0.5 inch screen.*
- *The media must be able to demonstrate a minimum of 30% porosity under field conditions (with overburden), and must be able to demonstrate the ability to uniformly distribute effluent across the length and width of the trench.*
- *All in-trench products should have a minimum storage volume equivalent to two days of design flow (i.e., 300 gallons per bedroom).*
- *Systems using EZFlow™1203 should be sized based on an absorption area of 4.66 ft^2/ft and a storage of 6.9 gal/ft.*
- *Sizing of systems using EZFlow™1401 should incorporate a storage volume of 2.86 gal/ft.*

Section Five: Designing for the Cross Section of Various In-Trench Products

Cross-Section

As excavated, a trench has a horizontal bottom and vertical sidewalls. As crushed rock is poured into a trench, the rock takes the shape of the trench cross section. Rigid products (vaults, bundles, LDGP, etc) will retain their shape and may not fully expose effluent to the in-trench absorption area. Design adjustments must be made to account for the product's cross section relative to the trench cross section. In this section, products will be divided into two categories - flat bottom and cylindrical.

Flat Bottom Products

Relative to the overall trench width, flat bottom products have infiltrative areas that are parallel to the trench bottom. Examples of flat bottom products include vaults, bundled pipe, and bundles of porous media. Several manufacturers have products that are not the same width as "standard" excavator buckets. As previously discussed, a 32-inch wide vault is placed in a 36-inch wide trench. This situation requires that fill material be placed between the non-disturbed sidewall and the vault. Disturbed soil no longer has structure or pore conductivity. This reduces the effectiveness of the sidewall. Therefore, it is proposed by this document that the bottom width of the product determines the bottom portion of the absorption area, not the excavated trench width. For example, a vaulted product that is 32 inches wide and has 10-inch side louvers would have a total absorption area 3.67 ft^2/ft of length. This value is derived from two, six-inch sidewalls plus the 32-inch wide bottom.

Cylindrical In-Trench Products

Manufacturers have developed porous media products that have a circular cross-section rather than rectangular. Because excavation equipment creates a flat trench bottom, there is a natural gap between the cylindrical product's exterior surface and the trench bottom and sidewall. The research literature does not provide much guidance as to whether this disconnect with the infiltrative surface is a significant effect.

Large Diameter Gravelless Pipe

Large diameter gravelless pipe (LDGP) is an in-trench system that is composed of 8” or 10” diameter pipe that is enclosed within a fabric sock. The pipe has two rows of perforations about 57 to 62 degrees up from the bottom centerline of the pipe. This configuration allows for the transmission of effluent along the length of the trench, provides open volume for storage, and purports to provide an interface for effluent to enter the soil.

Historically, LDGP has been sized assuming that the outer circumference of the product is the absorptive surface area. And frankly, a lot of this product has been successfully installed and utilized using this sizing strategy. However, there is much discussion as to whether the full outer circumference is a reasonable design criterion.

Anderson et al. (1985) produced one of the original studies concerning LDGP. The two stated goals of their research were to determine the long term acceptance rate of the gravelless product and to investigate the formation and location of the biomat associated with LDGP. This paper presented an argument that the actual soil contact area between a 10-inch diameter the LDGP and the soil is only 1.35 square feet per foot of length. This value accounts for the corrugations that are in direct contact with the soil and therefore serve as to mask the soil interface. LDGP manufacturers and politicians were successful in convincing many regulatory agencies that the whole surface area (3.12 ft^2 per ft of length) should be used as the infiltrative surface, and as such, one foot of 10-inch diameter LDGP became equivalent to a three foot wide trench.

Chapter 1200-1-6 (Table v.) assumes that a 10-inch LDGP is equivalent to a three-foot wide, rock-filled trench, and that 8-inch diameter LDGP is equivalent to two-foot wide, rock-filled trench. As mentioned above, this sizing configuration is based on the circumference of the LDGP. The excavated trench for either configuration can be as narrow as 18 inches (for soils listed less than 60 mpi) and 24 inches in soils 60 mpi and greater.

Only for the purpose of comparing loading rates among products, this report assumed that the “as-excavated” trench bottom should serve as the infiltrative surface. This assumption is only validated from the fact that this surface is the interface between disturbed and non-disturbed soil. As shown in tables 8 and 9, the assumption was made that LDGP would be installed in an 18-inch wide trenches in soils less than or equal to 60 mpi, and they would be installed in 24-inch wide trenches for soil rated greater than 60 mpi.

Again, these tables assumed that the excavated trench bottom is the infiltrative surface. With this assumption, the loading rate values in table 8 match the recommended “fines free” loading rate given in table 4. However, the values in table 9 are significantly greater than the suggested loading rates.

There is not a modern research article that defends the continued practice calling a 10-inch LDGP equivalent to a three-foot trench. A very legitimate question becomes what is this the actual absorption surface area created by LDGP? Several states have addressed this issue in their codes. Nebraska uses 75% of the circumference as the effective width of the trench bottom (Title 124 Chapter 14, Nebraska Dept. of Environmental Quality). For a nominal 10-inch diameter LDGP, this would yield 2.34 square feet of trench bottom per foot of length. Minnesota is proposing to amend their code to suggest that one foot of 10-inch LDGP is only equivalent to one square foot of trench bottom area. South Carolina has 10-inch diameter LDGP listed as having the equivalent of 2.5 square feet of trench bottom area per foot of pipe. Washington has mandated that all gravelless pipe products have an effective trench width

Table 8. Current loading rates of 8" diameter large diameter gravelless pipe.

Soil Rating mpi	8" LDGP Trench Length per Bedroom (ft)	Trench Area (Width 18"or 24" >60 mpi) per Bedroom (ft^2)	Loading Rate (gpd/ft^2)
10	83	125	1.20
15	95	143	1.05
30	125	188	0.80
45	150	225	0.67
60	165	248	0.61
75	185	370	0.41
80	190	380	0.39
85	195	390	0.38
90	200	400	0.38
95	208	416	0.36
100	215	430	0.35
105	223	446	0.34

Table 9. Current loading rates of 10" diameter large diameter gravelless pipe.

Absorption Rate mpi	10" LDGP Trench Length per Bedroom (ft)	Trench Area (Width 18"or 24" >60 mpi) per Bedroom (ft^2)	Loading Rate (gpd/ft^2)
10	55	83	1.80
15	64	96	1.56
30	84	126	1.19
45	100	150	1.00
60	110	165	0.91
75	124	248	0.60
80	126	252	0.60
85	130	260	0.58
90	134	268	0.56
95	139	278	0.54
100	144	288	0.52
105	149	298	0.50

equal to the outside diameter of the product. Table 10 provides a partial listing of how various States regulate the use of LDGP.

Table 10. Partial listing of States and how they regulate large diameter gravelless pipe (LDGP)[a].

Rules	Location
States that do not allow LDGP	Pennsylvania, Rhode Island, Vermont, Wyoming, Maryland, Utah, California, Montana, Nevada, New Mexico, Oregon, Ohio, Indiana, Wisconsin, Massachusetts
States that have LDGP in their code but do not specify trench width equivalency	Georgia, Colorado, New Jersey, West Virginia, North Carolina, North Dakota, Arizona, Connecticut, Oklahoma, South Dakota, Minnesota, New York, Delaware, Hawaii, Florida, Idaho, Iowa, Louisiana, Maine, Missouri
States with codes that specify trench width equivalency for LDGP	
8” diameter LDGP = 18” trench 10” diameter LDGP = 24” trench	Illinois, Kentucky, Arkansas
8” diameter LDGP = 24” trench 10” diameter LDGP = 36” trench	Alabama, Tennessee Texas (8” dia. = 24”, 10” dia. = 32”)
10” diameter LDGP = 30” trench	South Carolina
10” diameter LDGP = 10” trench	Washington
Trench width = 75% of LDGP circumference	Nebraska

[a] The above information was found from each State’s onsite wastewater regulatory website.

Proposed LDGP Sizing Method

It is proposed that LDGP should be sized such than the absorption surface area per foot of length is three-quarters of the outer circumference. In other words, a 10-inch diameter (11.9-inch O.D.) LDGP would be equivalent to 2.34 square feet per foot of length (ft^2/ft). Eight-inch diameter (9.55-inch O.D.) LDGP would have an absorption surface area of 1.88 ft^2/ft. A LDGP system would then be sized using the required absorption area (table 5) and then the linear trench footage required would be determined based on the soil and wastewater volume.

It is also recommended that trenches should be excavated to the product width. There is concern about putting a 10-inch diameter LDGP pipe in a 24-inch wide trench. The backfill material has no structure and has lost pore connectivity and continuity. This disturbed soil will likely hinder the water movement to the non-disturbed soil interface. It is therefore suggested that 8-inch and 10-inch LDGP systems should have a maximum 12-inch trench width.

Implications for the Installation of LDGP

Using the absorption area to determine the LDGP length required demands that additional LDGP is needed compared to current regulation. This increase is slightly offset by using the “fines-free” soil absorption loading rate.

In soils greater than 60 mpi, Tennessee requires that LDGP be installed in 24-inch wide trench that is backfilled with approved crushed rock. The author supports this rule, but would amend it such that when eight-inch diameter LDGP is placed in a 24-inch, crushed rock-filled trench – the trench length should now be based on an absorption area of 3.33 ft^2/ft (two 8-inch sidewalls and a 24-inch bottom). Likewise, when 10-inch diameter LDGP is placed in a 24-inch wide trench with crushed rock, the trench length should be based on 3.67 ft^2/ft. When the crushed rock is used, both of these products would use the same required absorption area as crushed rock. These notions are reflected in the shaded area of table 11.

Table 11. Implications of proposed sizing criteria on LDGP trench length (on a per bedroom basis).

Soil Rating mpi	Absorption Area Required per Bedroom ft^2	Current 8-inch LDGP ft	Proposed 8-inch LDGP ft	Current 10-inch LDGP ft	Proposed 10-inch LDGP ft
10	195[a]	83	104[c]	55	83[d]
15	220	95	117	64	94
30	290	125	154	84	124
45	350	150	186	100	150
60	385	165	205	110	165
75	617[b]	185	185[e]	124	168[f]
80	633	190	190	126	172
85	650	195	195	130	177
90	667	200	200	134	182
95	692	208	208	139	189
100	717	215	215	144	195
105	742	223	223	149	202

[a] Fines-free loading rate.
[b] With fines loading rate.
[c] Length is based on 1.88 ft^2/ft.
[d] Length is based on 2.34 ft^2/ft.
[e] Length is based on 3.33 ft^2/ft.
[f] Length is based on 3.67 ft^2/ft

EZFlow™ 1401

As discussed in Section 4, EZFlow™ 1401 has a 14-inch outer diameter and can be installed in a narrow trench. Currently, the trench length is determined on a foot-per-foot basis with a three-foot wide crushed rock system. It is proposed to size EZFlow™ 1401 using the same procedure outlined for LDGP – using three-quarters of the outer circumference as the infiltrative surface. As mentioned in Section Four, there is some consolidation and compaction of the void volume within the polystyrene product.

Determining the infiltrative surface of EZFlow 1401 is a challenge. Because the compressed product is no longer cylindrical, an effective diameter was assumed.

Using the compressed cross sectional area (132 in^2), a diameter was found by assuming the cross sectional area formed a circle. A 13-inch diameter produces a circular area of 132 in^2. Assuming 75% of the circumference as the infiltrative surface produces 2.55 ft^2/ft. As shown in table 12, this new methodology increases the required length of EZFlow 1401 by about 37%. Trench storage was the limiting factor in soils rated 10 and 15 mpi. This product should be installed in 18-inch wide trench.

Table 12. Length of EZFlow 1401 required to provide absorption area and/or storage in Tennessee's rated soils (on a per bedroom basis).

Soil Rating (mpi)	Current 1401H Trench Length per Bedroom (ft)	Fines Free Absorption Area Required per Bedroom (ft^2)	Proposed 1401 Trench Length per Bedroom[a] (ft)	Storage per Bedroom[b] (gallons)
10	55	195	105	300
15	63	220	105	300
30	83	290	114	326
45	100	350	137	392
60	110	385	151	432
75	123	430	169	483
80	127	445	175	501
85	130	455	178	509
90	133	465	182	521
95	138	485	190	543
100	143	500	196	561
105	148	520	204	583

[a] Assumes 2.55 ft^2/ft.
[b] Assumes 2.86 gal/ft.

Section Five Recommendations:

- *The maximum absorption area allowed for in-trench products with cylindrical cross-sections should be based on 75% of the products' outer circumference.*
- *Eight-inch diameter LDGP should be sized based on 1.88 ft^2/ft of trench.*
- *Ten-inch diameter LDGP should be sized based on 2.34 ft^2/ft of trench.*

- *For LDGP, the maximum trench width should be 12 inches, unless in soils rated greater than 60 mpi.*
- *EZFlow 1401 should be installed using an infiltrative surface of 2.55 ft^2/ ft of trench and installed in an 18-inch wide trench.*

Section Six: Additional Products

Other Trench Products

Using the recommended methodology, all other in-trench systems would be sized based on the actual exposure of effluent to the absorption area. This procedure is both logical and defendable.

In-Trench Vaults

As proposed in Section Three, vaulted products cannot yield the same ponding as porous media products. It is recommended that six inches of sidewall should be the maximum allowed for vaulted products. Currently 32-inch wide products are sized the same as 36-inch wide products, which means that these systems have 11 percent less infiltrative surface. By the recommended methodology, a 32-inch wide vaulted product will be sized according to 3.67 ft^2/ft. Table 13 demonstrates how the proposed methodology will affect 32-inch wide vaulted products.

Vaults that are 24 and 22-inch wide are also available. These two widths are currently sized as equivalent to three-foot wide, rock-filled trenches with no linear reduction. By setting the absorption area to match the width of the vault plus six inches on each sidewall, 24-inch wide products should be sized on the basis of 3.00 ft^2/ft and 22-inch wide products should be sized as 2.83 ft^2/ft. Table 13 contains current and proposed 22-inch wide trench lengths. The proposed lengths are based on the fines-free loading rate.

Narrow Vaults

Currently narrow vaults (16-inch) products are sized as equivalent to three-foot wide, rock-filled trenches with 125% increase in length. By the suggested sizing method, each foot of 16-inch wide vaulted product would have 2.33 square feet of infiltrative surface area per foot of trench length. Table 14 provides a listing of how this sizing system would affect the installation of this product.

Table 13. Current and proposed trench lengths for 32” and 22” wide vaulted products on a per bedroom basis.

Soil Rating mpi	Current Trench Length per Bedroom for 32” Vaults (ft)	Proposed Trench Length per Bedroom for 32” Vaults[a] (ft)	Current Trench Length per Bedroom for 22” Vaults (ft)	Proposed Trench Length per Bedroom for 22” Vaults[b] (ft)
10	39	53	55	69
15	44	60	63	78
30	58	79	83	102
45	70	95	100	124
60	77	105	110	136
75*	123	117 [a]	123	152 [a]
80*	127	121	127	157
85*	130	124	130	161
90*	133	127	133	164
95*	138	132	138	171
100*	143	136	143	177
105*	148	142	148	184

* Sites with soil absorption rates less that 60 mpi are currently not allowed length reductions.
[a] It is proposed that length reductions be allowed in all rated soils.
[b] Absorption area is 3.67 ft^2/ft
[c] Absorption area is 2.83 ft^2/ft.

Bundled-Pipe and Other Trench Media Products

By this proposed sizing method, bundled pipe and other future products would have an infiltrative surface based on the width of the product and based on the cleanliness of the product (fines). Bundled pipe with a bottom dimension of 36 inches would have an infiltrative surface of 3 ft^2/ft and should be sized using the higher loading rate and the daily wastewater volume.

Table 14. Current and proposed trench lengths for 16” vaulted products on a per bedroom basis.

Soil Rating mpi	Current 16-inch Vault Trench Length per Bedroom (ft)	Proposed Sizing based on Narrow Trench Criterion[a] (ft)
10	69	84
15	79	94
30	104	124
45	125	150
60	138	165
75	154	184
80	158	191
85	163	195
90	167	199
95	173	208
100	179	214
105	185	223

[a] Based on 2.33 ft^2/ft and fines-free absorption rate.

Section Seven: Trench Spacing

Background

There is a long history of installing three-foot wide trenches with six feet of undisturbed soil between trenches. Yet, there is little science to support this methodology. Whereas the recommendations in this report will result in more trench bottom area for many of the in-trench technologies, there is little reason why narrower trenches could not be closer together. By using specific application rates for specific soils (rather than for specific in-trench technologies), narrow trench systems will have the same infiltrative area as wide trench systems. As a means of exploring the implications of reducing the undisturbed area, tables 15-24 have been created to show how the size of a three-bedroom soil absorption system would change if a rule were created that suggested the undisturbed width between trenches should be twice the trench width. The minimum and maximum trench width would be one foot and three feet, respectively. As used in the following tables, the areal loading rate is the wastewater volume spread over the entire soil absorption area, which includes the area between the trenches.

It is recognized that one of the issues with placing trenches closer together is the physical installation. With the wider trench spacing, the tires (or tracks) from the excavation equipment does not sit on top of the previously installed trench. Tennessee regulation does not allow the trench to be closed without inspection. Maintaining an open trench while excavating an adjacent trench may prove problematic to the installer when installing a narrow trench system.

Section Seven Recommendations:

- *Consider a methodology of having the area between the trenches be twice as wide as the trench.*
- *Gravelless pipe would go in one foot wide trenches with two feet between trenches.*
- *EZFlow™1401 and 16" chambers would go in 18" trenches with three feet between trenches.*
- *24" chambers and 24" crushed rock would go in two-foot trenches with four feet between trenches; and.*
- *32" and 36" chambers, EZFlow™ 1203, and 36" crushed rock would go in three-foot wide trenches with six feet between trenches.*

Table 15. Areal loading rate of crushed rock in 36-inch wide trenches with six feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	275	3	165	2	83	6	990	0.45
15	317	3	190	2	95	6	1141	0.39
30	417	3	250	3	83	6	1751	0.26
45	500	3	300	3	100	6	2100	0.21
60	550	3	330	4	83	6	2475	0.18
75	617	3	370	4	93	6	2777	0.16
80	633	3	380	4	95	6	2849	0.16
85	650	3	390	4	98	6	2925	0.15
90	667	3	400	5	80	6	3122	0.14
95	692	3	415	5	83	6	3239	0.14
100	717	3	430	5	86	6	3356	0.13
105	742	3	445	5	89	6	3473	0.13

Table 16. Areal loading rate of crushed rock in 24-inch wide trenches with four feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	275	2	206	3	69	4	1169	0.39
15	317	2	238	3	79	4	1347	0.33
30	417	2	313	4	78	4	1877	0.24
45	500	2	375	4	94	4	2250	0.20
60	550	2	413	5	83	4	2558	0.18
75	617	2	463	5	93	4	2869	0.16
80	633	2	475	5	95	4	2943	0.15
85	650	2	488	5	98	4	3023	0.15
90	667	2	500	6	83	4	3168	0.14
95	692	2	519	6	87	4	3287	0.14
100	717	2	538	6	90	4	3406	0.13
105	742	2	557	6	93	4	3525	0.13

Table 17. Areal loading rate of EZFlow 1203 in 36-in wide trenches with six feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	3	125	2	63	6	752	0.60
15	220	3	141	2	71	6	848	0.53
30	290	3	186	2	93	6	1118	0.40
45	350	3	225	3	75	6	1574	0.29
60	385	3	247	3	82	6	1731	0.26
75	430	3	276	3	92	6	1934	0.23
80	445	3	286	3	95	6	2001	0.22
85	455	3	292	3	97	6	2046	0.22
90	465	3	299	3	100	6	2091	0.22
95	485	3	312	4	78	6	2337	0.19
100	500	3	321	4	80	6	2409	0.19
105	520	3	334	4	84	6	2505	0.18

Table 18. Areal loading rate of EZFlow 1401 in 18-in wide trenches with three feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	1.5	229	3	76	3	1147	0.39
15	220	1.5	259	3	86	3	1294	0.35
30	290	1.5	341	4	85	3	1791	0.25
45	350	1.5	412	5	82	3	2224	0.20
60	385	1.5	453	5	91	3	2446	0.18
75	430	1.5	506	6	84	3	2782	0.16
80	445	1.5	524	6	87	3	2879	0.16
85	455	1.5	535	6	89	3	2944	0.15
90	465	1.5	547	6	91	3	3009	0.15
95	485	1.5	571	6	95	3	3138	0.14
100	500	1.5	588	6	98	3	3235	0.14
105	520	1.5	612	7	87	3	3408	0.13

Table 19. Areal loading rate of 8-inch diameter LDGP in one- or two-foot wide trenches with two or four feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	1	311	4	78	2	1400	0.32
15	220	1	351	4	88	2	1580	0.28
30	290	1	463	5	93	2	2129	0.21
45	350	1	559	6	93	2	2606	0.17
60	385	1	614	7	88	2	2896	0.16
75	617	2	556	6	93	4	3520	0.13
80	633	2	570	6	95	4	3612	0.12
85	650	2	586	6	98	4	3709	0.12
90	667	2	601	7	86	4	3863	0.12
95	692	2	623	7	89	4	4008	0.11
100	717	2	646	7	92	4	4153	0.11
105	742	2	668	7	95	4	4297	0.10

Table 20. Areal loading rate of 10-inch diameter LDGP in one- or two-foot wide trenches with two or four feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	1	250	3	83	2	1083	0.42
15	220	1	282	3	94	2	1222	0.37
30	290	1	372	4	93	2	1673	0.27
45	350	1	449	5	90	2	2064	0.22
60	385	1	494	5	99	2	2271	0.20
75	617	2	504	6	84	4	3194	0.14
80	633	2	517	6	86	4	3277	0.14
85	650	2	531	6	89	4	3365	0.13
90	667	2	545	6	91	4	3453	0.13
95	692	2	566	6	94	4	3583	0.13
100	717	2	586	6	98	4	3712	0.12
105	742	2	607	7	87	4	3899	0.12

Table 21. Areal loading rate of 36-inch wide vaulted product with 36-inch wide trenches and six feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	3	146	2	73	6	878	0.51
15	220	3	165	2	83	6	990	0.45
30	290	3	218	3	73	6	1523	0.30
45	350	3	263	3	88	6	1838	0.24
60	385	3	289	3	96	6	2021	0.22
75	430	3	323	4	81	6	2419	0.19
80	445	3	334	4	83	6	2503	0.18
85	455	3	341	4	85	6	2559	0.18
90	465	3	349	4	87	6	2616	0.17
95	485	3	364	4	91	6	2728	0.16
100	500	3	375	4	94	6	2813	0.16
105	520	3	390	4	98	6	2925	0.15

Table 22. Areal loading rate of 32-inch wide vaulted product in 36-inch wide trenches with six feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	3	159	2	80	6	956	0.47
15	220	3	180	2	90	6	1079	0.42
30	290	3	237	3	79	6	1659	0.27
45	350	3	286	3	95	6	2003	0.22
60	385	3	315	4	79	6	2360	0.19
75	430	3	351	4	88	6	2636	0.17
80	445	3	364	4	91	6	2728	0.16
85	455	3	372	4	93	6	2790	0.16
90	465	3	380	4	95	6	2851	0.16
95	485	3	396	4	99	6	2973	0.15
100	500	3	409	5	82	6	3188	0.14
105	520	3	425	5	85	6	3316	0.14

Table 23. Areal loading rate of 24-inch wide vaulted product in 24-inch wide trenches with four feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	2	195	2	98	4	975	0.46
15	220	2	220	3	73	4	1247	0.36
30	290	2	290	3	97	4	1643	0.27
45	350	2	350	4	88	4	2100	0.21
60	385	2	385	4	96	4	2310	0.19
75	430	2	430	5	86	4	2666	0.17
80	445	2	445	5	89	4	2759	0.16
85	455	2	455	5	91	4	2821	0.16
90	465	2	465	5	93	4	2883	0.16
95	485	2	485	5	97	4	3007	0.15
100	500	2	500	5	100	4	3100	0.15
105	520	2	520	6	87	4	3293	0.14

Table 24. Areal loading rate of 16-inch wide vaulted product in 18-inch wide trenches with three feet between trenches (three-bedroom home).

Soil Rating (mpi)	Required Absorption Area per Bedroom (ft^2)	Trench Width (ft)	Total Trench Length (ft)	Number of. Trenches	Each Trench Length (ft)	Undisturbed Width (ft)	Yard Area (ft^2)	Areal Application Rate (gpd/ft^2)
10	195	1.5	251	3	84	3	1255	0.36
15	220	1.5	283	3	94	3	1416	0.32
30	290	1.5	373	4	93	3	1960	0.23
45	350	1.5	451	5	90	3	2433	0.18
60	385	1.5	496	5	99	3	2677	0.17
75	430	1.5	554	6	92	3	3045	0.15
80	445	1.5	573	6	95	3	3151	0.14
85	455	1.5	586	6	98	3	3222	0.14
90	465	1.5	599	6	100	3	3293	0.14
95	485	1.5	624	7	89	3	3479	0.13
100	500	1.5	644	7	92	3	3587	0.13
105	520	1.5	670	7	96	3	3730	0.12

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